THE GEOGRAPHIC DISTRIBUTION OF *TILLETIA* SPP. ON WHEAT IN AUSTRALIA IN 1931.

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(Two Text-figures.)

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Introduction.

Bunt or stinking smut of wheat has been known since early times and annually causes losses, more or less severe, in all wheat-growing countries.

The two common species causing the disease are *Tilletia tritici* (Bjerk.) Winter, the rough-spored type, and *Tilletia levis* Kuhn., with a smooth spore wall. Recently, Mitra (1931) has reported a new species of bunt, *Tilletia indica*, on wheat in India. It has a reticulate spore wall like *T. tritici*, but differs from the latter in having no smell of rotten fish when crushed, and in attacking only portion of the grain. The chlamydospores, with an average diameter of 35μ, are considerably larger than those of *T. tritici* (20μ).

No extensive survey of the species of *Tilletia* causing bunt of wheat has hitherto been made in Australia, and work of this nature is very desirable. Bunt can be controlled readily by pickling the seed wheat, but the relatively high cost of this operation has already been stressed in an earlier paper (Churchward, 1931). Furthermore, the fact that bunt is present in all the wheat-growing States in Australia indicates that some farmers either do not "pickle" their wheat, or do it carelessly. For these reasons the best solution of the problem would seem to lie in the production of bunt-resistant varieties; obviously one of the prime requisites in breeding resistant varieties is to know the geographic distribution and relative prevalence of the two species of *Tilletia* causing the disease, as it is known that wheat varieties do not necessarily react in the same manner to both. Wheat varieties differ also in their resistance to several known physiological forms of bunt. This differential reaction has not been demonstrated in Australia and the present survey would serve as an introduction to future work on these lines.

Little work has been done previously in studying the geographic distribution of the species of bunt. In America, Coons and Potter (1918) reported that the States of the Upper Mississippi Valley and the Great Plains area were fairly free of *T. tritici*. Tisdale et al. (1927) later found this species in the Mississippi Valley, but it was confined to the durum wheats.

T. tritici was the only species found in the State of Washington prior to 1918, and in the following year an extensive survey showed *T. levis* to be present in only two of the 631 fields examined (Kienholz and Heald, 1930). In 1927-28 the amount of *T. levis* was found to have increased, though *T. tritici* was still predominant.

In general, it seems that *T. tritici* is most common west of the Rocky Mts., but may be found eastward as far as Illinois. *T. levis* is found from coast to coast, but is most prevalent in the east.

Both species are known to occur in Canada. The durums appear to be more susceptible to *T. tritici* than to *T. levis* (Hanna and Popp, 1930). Both species are found in the Hard Red Spring wheats, but *T. tritici* is more common in the crops of the northern areas, while *T. levis* predominates in the south.

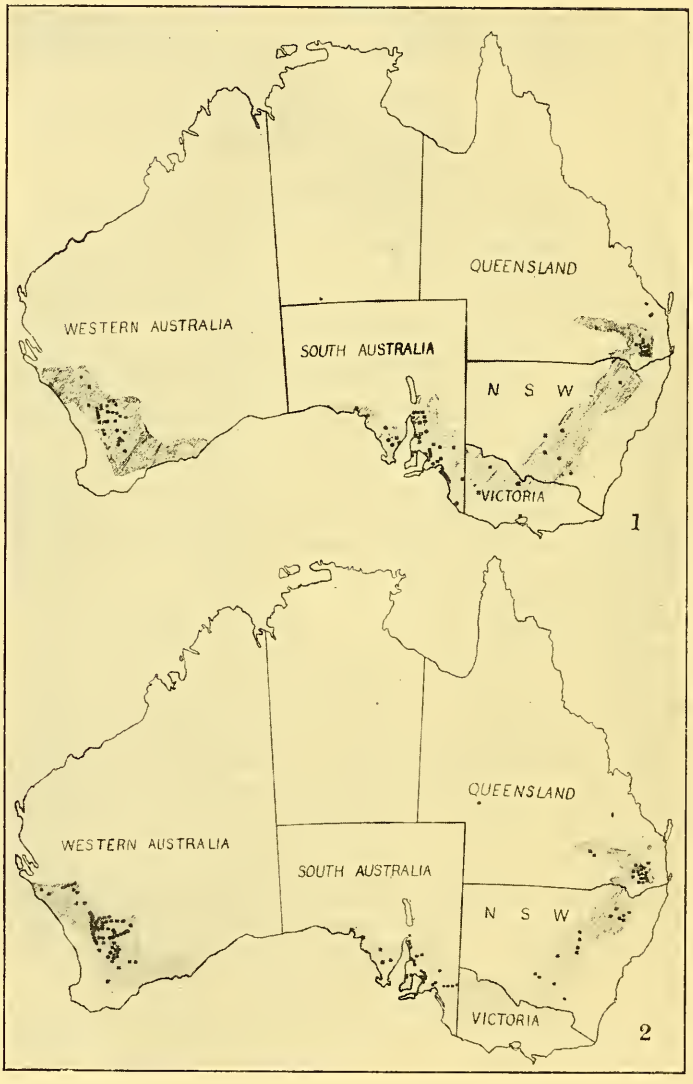

Fig. 1.—The distribution of *Tilletia tritici* in Australia in 1931.
Fig. 2.—The distribution of *Tilletia levis* in Australia in 1931.
The shaded area indicates the approximate limits of the wheat-growing area. Each square represents a centre from which one or more collections have been made.

There were noted only few references to the distribution of the species in Europe. According to Gram (1929) *T. tritici* is the predominant species of bunt in Denmark, the incidence of *T. levis* being almost negligible. Butler states that *T. levis* is rare in England. In Bulgaria, *T. levis* occurs practically over all the country while *T. tritici* is restricted to two separate highland areas; one in the middle of the Danubian Plain, the other in the extreme north-west (Atanasoff, 1929). Andreyeff (1928) has shown that, in the North Caucasian Region, 90% of the total infection is due to *T. levis*. The incidence of *T. tritici* increases from south to north.

Results of Survey.

At the close of the 1931 wheat season, with the co-operation of certain wheat exporting firms and Departments of Agriculture of the various States, collections of bunt were made in all the principal wheat-growing districts of the five States in Australia. Some collections were made in the field, others were obtained from bulk smutty wheat, from various country centres or on arrival at shipping port.*

From each of these representative lots a random sample was taken, and from this 10–20 bunt balls were selected. The contents of a ball were broken into a drop of 50% aqueous solution of lactic acid and the spore suspension examined. The results are summarized in Table I and the distribution of the species of *Tilletia* of wheat is graphically represented in Figures 1 and 2.

The shaded areas indicate the approximate limits of the wheat belts in the various States. Each black square represents a centre from which one or more collections have been made. The composite collections comprise numbers of bunt balls taken from many samples of wheat and are, therefore, truly representative of each district.

Table I shows that bunt is present in all of the principal wheat-growing districts of the five States and that *T. levis* predominates. Both species were found in all of the States except Victoria; here only *T. tritici* was collected. Even though the samples examined from a wheat cleaning plant in Melbourne proved to be *T. tritici* only, it is probable that, had collections been received from more centres, *T. levis* would have been found.

TABLE I.—*The species of bunt of wheat in different localities of five wheat-growing States of Australia.*

Locality and Number of Samples.	Species of *Tilletia* present.	Locality and Number of Samples.	Species of *Tilletia* present.
	Queensland.		
Amby (1)	*levis*	Millmerran (3) ..	*levis*
Hodgson (2) ..	*tritici* and *levis*	Greenmount (1)	*tritici* and *levis*
Dalby (3)	*levis*	Nobby (4)	*tritici* and *levis*
Goombungee (1)	*levis*	Clifton (7)	*tritici* and *levis*
Oakey (3)	*tritici* and *levis*	Ellinthrop (2) ..	*tritici* and *levis*
Kingsthorpe (1)	*levis*	Allora (6)	*tritici* and *levis*
Aubigny (1) ..	*tritici* and *levis*	Berat (2)	*tritici* and *levis*
Boora Mugga (4)	*tritici* and *levis*	Cunningham (2)	*tritici* and *levis*
Cecil Plains (1)	*tritici* and *levis*	Warwick (4) ..	*tritici* and *levis*
Umbrian (1) ..	*tritici* and *levis*	Yangan (6) ..	*tritici* and *levis*
Pittsworth (5) ..	*tritici* and *levis*		

* It is desired to acknowledge the assistance rendered and the facilities placed at my disposal by the Field Instructors of the various State Departments of Agriculture. by the staff of the Hawkesbury Agricultural College, and by Bunge (Aust.) Pty. Ltd., Dalgety & Co. Ltd., John Darling & Son, Ltd., and Louis Dreyfus & Co.

Locality and Number of Samples.	Species of *Tilletia* present.	Locality and Number of Samples.	Species of *Tilletia* present.
New South Wales.			
Gravesend (3) ..	*tritici* and *levis*	Derriwong (1) ..	*tritici* and *levis*
Inverell (1) ..	*levis*	Cumnock (1) ..	*levis*
Wee Waa (2) ..	*levis*	Larras Lee (1) ..	*levis*
Somerton, Manilla (2)	*levis*	Wagga Wagga (2)	*tritici* and *levis*
Tamworth (2) ..	*tritici* and *levis*	Leeton (1)	*tritici* and *levis*
Warrah Ridge (1)	*levis*	Goolgowi (1) ..	*tritici* and *levis*
Wangarbon (1)..	*levis*	Goorawin (1) ..	*tritici* and *levis*
Gilgandra (1) ..	*levis*	Lake Cargelligo (1)	*tritici*
Victoria.			
Melbourne (composite)	*tritici*	Werribee (composite)	*tritici*
Rutherglen (2) ..	*tritici*	Sea Lake (1) ..	*tritici*
Horsham (2) ..	*tritici*		
South Australia.			
Millicent (1) ..	*tritici*	Port Rickaby (1)	*tritici* and *levis*
Wolseley (2) ..	*tritici*	Minlacowie (1)	*tritici*
Pinaroo (1) ..	*levis*	Maitland (1) ..	*tritici*
Parilla (1)	*levis*	Kilkerran (2) ..	*levis*
Parrakie (1) ..	*levis*	Paskeville (1) ..	*tritici* and *levis*
Wilkawatt (1) ..	*levis*	Kadina (3) ..	*tritici* and *levis*
Karri (1)	*tritici*	Wallaroo (1) ..	*tritici* and *levis*
Monarto (4) ..	*tritici* and *levis*	Port Germein (1)	*tritici* and *levis*
Sutherlands (1)	*tritici* and *levis*	Black Rock (1)	*tritici*
Eudunda (1) ..	*tritici*	Moocra (1) ..	*tritici*
Murray Bridge (1)	*tritici* and *levis*	Bruce (1)	*tritici* and *levis*
Woodchester (1)	*tritici*	Carrieton (1) ..	*tritici*
Owen (1)	*levis*	Ungarra (1) ..	*tritici*
Gawler (2)	*tritici* and *levis*	Karkoo (1) ..	*tritici* and *levis*
Wasleys (1) ..	*tritici* and *levis*	Wharminda (1)	*tritici* and *levis*
Alma (2)	*tritici* and *levis*	Dutton Bay (1)	*tritici*
Dublin (2)	*tritici* and *levis*	Warramboo (1)	*tritici* and *levis*
Saddleworth (1)	*tritici*	Denial Bay (1)	*tritici* and *levis*
Blyth (1)	*tritici* and *levis*	Streaky Bay (1)	*tritici* and *levis*
Jamestown (1) ..	*tritici*	Nowral (1) ..	*tritici* and *levis*
Gladstone (2) ..	*tritici*	Tarke (2)	*tritici* and *levis*
Bute (1)	*tritici* and *levis*	Petersville (1) ..	*tritici*
Port Pirie (1) ..	*tritici* and *levis*	Perlubie (2) ..	*tritici* and *levis*
Wandearah (1) ..	*levis*	Mundalla (1) ..	*tritici*
Western Australia.			
Collie (1)	*tritici*	Beverley (1) ..	*tritici*
Broome Hill (1)	*levis*	Quairading (2) ..	*levis*
Tarin Rock (1) ..	*tritici* and *levis*	Burgess Siding (1)	*levis*
Lake Biddy (2)	*levis*	Hammersley (1)	*levis*
Newdegate (2) ..	*levis*	Nangeenan (2) ..	*tritici* and *levis*
Harrismith (2)	*tritici* and *levis*	Nungarin (1) ..	*tritici* and *levis*
Dudinin (1) ..	*tritici* and *levis*	Elabbin (1) ..	*tritici* and *levis*
Traysurin (2) ..	*tritici* and *levis*	Merriden (2) ..	*levis*
Wickipin (2) ..	*levis*	Burracoppin (1)	*levis*
Kulin (3)	*tritici* and *levis*	Carrabin (1) ..	*tritici* and *levis*
Gnarming (2) ..	*levis*	Bodallin (1) ..	*levis*
Kondinin (1) ..	*levis*	Moorine Rock (1)	*levis*
Bullaring (2) ..	*levis*	Perilya (1) ..	*levis*
Notting (1) ..	*tritici* and *levis*	Warralakin (1)	*levis*
Bendering (2) ..	*levis*	Campion (2) ..	*levis*
Corrigin (1) ..	*tritici* and *levis*	Mukinbudin (1)	*tritici* and *levis*
Ardath (2) ..	*levis*	Northam (1) ..	*tritici*
Brookton (2) ..	*tritici* and *levis*		

Locality and Number of Samples.	Species of *Tilletia* present.	Locality and Number of Samples.	Species of *Tilletia* present.
Western Australia—*Continued.*			
Tammin (2) ..	*tritici* and *levis*	Koorda (1) ..	*tritici* and *levis*
Cunderdin (1) ..	*tritici* and *levis*	Gobbin (1) ..	*levis*
Frenches Siding (1)	*levis*	Cleary (1)	*tritici* and *levis*
Rossmore (2) ..	*tritici* and *levis*	Dalgouring (2) ..	*tritici* and *levis*
Goomaling (1) ..	*tritici*	Watheroo (1) ..	*tritici* and *levis*
Dowerin (1) ..	*levis*	Nugadong (1) ..	*levis*
Amery (1) ..	*levis*	Wubin (1)	*levis*
Benjabbering (1)	*levis*	Caron (1)	*tritici* and *levis*
Wyalkatchem (1)	*tritici* and *levis*	Three Springs (1)	*levis*
Trayning (1) ..	*tritici* and *levis*	Tardun (1) ..	*tritici* and *levis*
Burabadji (1) ..	*tritici* and *levis*	Wilroy (1) ..	*levis*
Goddard (1) ..	*tritici* and *levis*	Pindar (1)	*levis*
Elphin (1)	*tritici* and *levis*	Beatty (2)	*tritici* and *levis*
Manmanning (1)	*tritici* and *levis*	Mullewa (3) ..	*levis*
Kondut (1) ..	*tritici* and *levis*	Ardingly (3) ..	*levis*
Ballidu (2) ..	*levis*	Tenindewa (2) ..	*levis*
Damboring (1)	*levis*	Eradu (1)	*levis*
Cowcowing (1) ..	*levis*	Ajana (1)	*levis*
		Various sources	*tritici* and *levis*

Hitherto, it was generally held that there was little or no *T. tritici* in Western Australia, but the survey made by the writer indicates that the species is present and is fairly widespread. The invasion may have been a recent one.

In South Australia most of the collections came from typical mallee country and many from the newer mallee areas, where the standard of farming is not yet as high as is desired. The fairly wide distribution of bunt in these areas may possibly be correlated with the absence of pickling.

This is supported by the fact that in New South Wales, where dry pickling is practised by almost all wheat growers, bunt is not very abundant, although collections were obtained from most of the wheat-growing districts. It was believed formerly that *T. tritici* was the more common species in New South Wales. The results of the survey would indicate, however, that *T. levis* is the predominant species.

In Queensland *T. levis* was found in all centres from which collections were made. *T. tritici* was missing from only five collections.

Conclusions.

The results of the survey made by the writer show quite clearly that two species of *Tilletia*, namely *T. tritici* and *T. levis*, are widely distributed and prevalent in most of the wheat-growing areas of Australia. This fact has an important bearing on the development of disease-resistant varieties, as it has been shown by Johnston (1924), Kienholz and Heald (1930), and Holton (1930) that varieties do not necessarily react in the same way to the two species of bunt. Varieties may be resistant to one species but more susceptible to the other. Furthermore, Kienholz and Heald have shown that when one of the species is brought into a region in which the other seemed to predominate, varieties hitherto resistant to bunt may become infected. It was shown by Kienholz and others also that there are intergrading forms between the two species as indicated by the degree of reticulation of the spore wall. This suggests the possibility of inter-specific hybridization which might easily complicate the breeding problem and change its aspect from time to time.

The writer has found the same variation in collections made in Australia. It seems highly probable, therefore, that interspecific hybridization occurs here. Furthermore, it is now well known that there are many physiologic forms or parasitic strains within both species. While a thorough study of this physiologic specialization has not yet been made in Australia, it seems very likely that it must be taken into consideration in breeding work, and experiments are now under way to determine the number and distribution of forms, as well as the possible origin of new forms through hybridization.

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